## *CATEGORY 3 - ELECTRONICS*

## A. SYSTEMS, EQUIPMENT AND COMPONENTS

***Note 1:*** *The control status of equipment and components described in 3A001 or 3A002, other than those described in 3A001.a.3 to 3A001.a.10 or 3A001.a.12, which are specially designed for or which have the same functional characteristics as other equipment is determined by the control status of the other equipment.*

***Note 2:*** *The control status of integrated circuits described in 3A001.a.3 to 3A001.a.9 or 3A001.a.12 that are unalterably programmed or designed for a specific function for other equipment is determined by the control status of the other equipment.*

***N.B.:*** *When the manufacturer or applicant cannot determine the control status of the other equipment, the control status of the integrated circuits is determined in 3A001.a.3 to 3A001.a.9 and 3A001.a.12. If the integrated circuit is a silicon-based "microcomputer microcircuit" or microcontroller microcircuit described in 3A001.a.3 having an operand (data) word length of 8 bit or less, the control status of the integrated circuit is determined in 3A001.a.3.*

**3A001 Electronic components, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NS, MT, NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| MT applies to 3A001.a.1.a when usable in "missiles"; and to 3A001.a.5.a when "designed or modified" for military use, hermetically sealed and rated for operation in the temperature range from below -54ºC to above +125ºC. | MT Column 1 |
| NP applies to pulse discharge capacitors in 3A001.e.2 and superconducting solenoidal electromagnets in 3A001.e.3 that meet or exceed the technical parameters in 3A201.a and 3A201.b, respectively | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A for MT or NP
Yes for:
$1500: 3A001.c
$3000: 3A001.b.1, b.2, b.3, .d, .e and .f
$5000: 3A001.a (except a.1.a and a.5.a when controlled for MT), and .b.4 to b.7

GBS: Yes for 3A001.a.1.b, a.2 to a.12 (except .a.5.a when controlled for MT), b.2, and b.8 (except for TWTAs exceeding 18 GHz)

.● CIV: Yes for 3A001.a.3, a.4, a.7, and a.11.

**List of Items Controlled**

*Unit*: Number.

*Related Controls:* 1.) The following commodities are under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121) when "space qualified" and operating at frequencies higher than 31.8 GHz: helix tubes (traveling wave tubes (TWT)) defined in 3A001.b.1.a.4.c; microwave solid state amplifiers defined in 3A001.b.4.b traveling wave tube amplifiers

(TWTA) defined in 3A001.b.8; and derivatives thereof; 2.) "Space qualified" and radiation hardened photovoltaic arrays, as defined in 3A001.e.1.c, having silicon cells or having single, dual or triple junction solar cells that have gallium arsenide as one of the junctions, are subject to the export licensing authority of the Department of Commerce. All other "space qualified" and radiation hardened photovoltaic arrays defined in 3A001.e.1.c and spacecraft/satellite concentrators and batteries are under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121). See also 3A101, 3A201, and 3A991.

*Related Definitions*: For the purposes of integrated circuits in 3A001.a.1, 5 x $10^3$ Gy(Si) = 5 x $10^5$ Rads (Si); 5 x $10^6$ Gy (Si)/s = 5 x $10^8$ Rads (Si)/s. For purposes of photovoltaic arrays in 3A001.e.1.c, an array predominately consists of: a substrate; solar cells having silicon cells or having single, dual, and or triple junction solar cells that have gallium arsenide as one of the junctions; coverglass; ultra-violet coating(s); and bonding agent(s). Spacecraft/satellite: solar concentrators, power conditioners and or controllers, bearing and power transfer assembly, and or deployment hardware/systems are controlled under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121).

*Items*:

a. General purpose integrated circuits, as follows:

***Note 1*:** *The control status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 3A001.a.*

***Note 2*:** *Integrated circuits include the following types:*

*"Monolithic integrated circuits";*

*"Hybrid integrated circuits";*

*"Multichip integrated circuits";*

*"Film type integrated circuits", including silicon-on-sapphire integrated circuits;*

*"Optical integrated circuits".*

a.1. Integrated circuits, designed or rated as radiation hardened to withstand any of the following:

a.1.a. A total dose of 5 x $10^3$ Gy (Si), or higher;

a.1.b. A dose rate upset of 5 x $10^6$ Gy (Si)/s, or higher; *or*

a.1.c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of 5 x $10^{13}$ n/cm² or higher on silicon, or its equivalent for other materials;

***Note*:** *3A001.a.1.c does not apply to Metal Insulator Semiconductors (MIS).*

a.2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analog-to-digital converters, digital-to-analog converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable logic devices, neural network integrated circuits, custom integrated circuits for which either the function is unknown or the control status of the equipment in which the integrated circuit will be used in unknown, Fast Fourier Transform (FFT) processors, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), having any of the following:

a.2.a. Rated for operation at an ambient temperature above 398 K (125°C);

a.2.b. Rated for operation at an ambient temperature below 218 K (-55°C); *or*

a.2.c. Rated for operation over the entire ambient temperature range from 218 K (-55°C) to 398 K (125°C);

***Note*:** *3A001.a.2 does not apply to integrated circuits for civil automobile or railway train applications.*

● a.3. "Microprocessor microcircuits", "micro-computer microcircuits" and microcontroller microcircuits, manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz;

***Note*:** *3A001.a.3 includes digital signal processors, digital array processors and digital coprocessors.*

a.4. Storage integrated circuits manufactured from a compound semiconductor;

a.5. Analog-to-digital and digital-to-analog converter integrated circuits, as follows:

a.5.a. Analog-to-digital converters having any of the following:

a.5.a.1. A resolution of 8 bit or more, but less than 10 bit, an output rate greater than 500 million words per second;

a.5.a..2 A resolution of 10 bit or more, but less than 12 bit, with an output rate greater than 200 million words per second;

a.5.a.3. A resolution of 12 bit with an output rate greater than 50 million words per second;

a.5.a.4. A resolution of more than 12 bit but equal to or less than 14 bit with an output rate greater than 5 million words per second; *or*

a.5.a.5. A resolution of more than 14 bit with an output rate greater than 1 million words per second.

a.5.b. Digital-to-analog converters with a resolution of 12 bit or more, and a "settling time" of less than 10 ns;

***Technical Notes*:**

*1. A resolution of n bit corresponds to a quantization of 2n levels.*

*2. The number of bits in the output word is equal to the resolution of the analogue-to-digital converter.*

*3. The output rate is the maximum output rate of the converter, regardless of architecture or oversampling. Vendors may also refer to the output rate as sampling rate, conversion rate or throughput rate. It is often specified in megahertz (MHz) or mega samples per second (MSPS).*

*4. For the purpose of measuring output rate, one output word per second is equivalent to one Hertz or one sample per second.*

a.6. Electro-optical and "optical integrated circuits" designed for "signal processing" having all of the following:

a.6.a. One or more than one internal "laser" diode;

a.6.b. One or more than one internal light detecting element; *and*

a.6.c. Optical waveguides;

a.7. Field programmable logic devices having any of the following:

a.7.a. An equivalent usable gate count of more than 30,000 (2 input gates);

a.7.b. A typical "basic gate propagation delay time" of less than 0.1 ns; *or*

a.7.c. A toggle frequency exceeding 133 MHz;

***Note*:** *3A001.a.7 includes: Simple Programmable Logic Devices (SPLDs), Complex Programmable Logic Devices (CPLDs), Field Programmable Gate Arrays (FPGAs), Field Programmable Logic Arrays (FPLAs), and Field Programmable Interconnects (FPICs).*

***N.B.*:** *Field programmable logic devices are also known as field programmable gate or field programmable logic arrays.*

a.8. [RESERVED]

a.9. Neural network integrated circuits;

a.10. Custom integrated circuits for which the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:

a.10.a. More than 1,000 terminals;

a.10.b. A typical "basic gate propagation delay time" of less than 0.1 ns; *or*

a.10.c. An operating frequency exceeding 3 GHz;

a.11. Digital integrated circuits, other than those described in 3A001.a.3 to 3A001.a.10 and 3A001.a.12, based upon any compound semiconductor and having any of the following:

a.11.a. An equivalent gate count of more than 3,000 (2 input gates); *or*

a.11.b. A toggle frequency exceeding 1.2 GHz;

a.12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than (N log2 N)/20,480 ms, where N is the number of points;

***Technical Note*:** When N is equal to 1,024 points, the formula in 3A001.a.12 gives an execution time of 500 μs.

b. Microwave or millimeter wave components, as follows:

b.1. Electronic vacuum tubes and cathodes, as follows:

***Note 1*:** *3A001.b.1 does not control tubes designed or rated for operation in any frequency band which meets all of the following characteristics:*

*a) Does not exceed 31.8 GHz; and*

*b) Is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

***Note 2*:** *3A001.b.1 does not control non-"space-qualified" tubes which meet all the following characteristics:*

*a) An average output power equal to or less than 50 W; and*

*b) Designed or rated for operation in any frequency band which meets all of the following characteristics:*

*1) Exceeds 31.8 GHz but does not exceed 43.5 GHz; and*

*2) Is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

b.1.a. Traveling wave tubes, pulsed or continuous wave, as follows:

b.1.a.1. Operating at frequencies exceeding 31.8 GHz;

b.1.a.2. Having a cathode heater element with a turn on time to rated RF power of

less than 3 seconds;

b.1.a.3. Coupled cavity tubes, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;

b.1.a.4. Helix tubes, or derivatives thereof, with any of the following characteristics:

b.1.a.4.a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.5;

b.1.a.4.b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1; *or*

b.1.a.4.c. Being "space qualified";

b.1.b. Crossed-field amplifier tubes with a gain of more than 17 dB;

b.1.c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm$^2$;

b.2. Microwave monolithic integrated circuits (MMIC) power amplifiers having any of the following:

b.2.a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 4W (36 dBm) with a "fractional bandwidth" greater than 15%;

b.2.b. Rated for operation at frequencies exceeding 6 GHz up to and including 16 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;

b.2.c. Rated for operation at frequencies exceeding 16 GHz up to and including 31.8 GHz and with an average output power greater than 0.8W (29 dBm) with a "fractional bandwidth" greater than 10%;

b.2.d. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;

b.2.e. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 0.25W (24 dBm) with a "fractional bandwidth" greater than 10%; *or*

b.2.f. Rated for operation at frequencies exceeding 43.5 GHz.

***Note 1*: *3A001.b.2 does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.***

● ***Note 2*:** *The control status of the MMIC whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.2.a through 3A001.b.2.f, is determined by the lowest average output power control threshold.*

***Note 3*:** *Notes 1 and 2 following the Category 3 heading for A. Systems, Equipment, and Components mean that 3A001.b.2. does not control MMICs if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.*

● *b.3. Discrete microwave transistors having any of the following:*

b.3.a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and having an average output power greater than 60W (47.8 dBm);

b.3.b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and having an average output power greater than 20W (43 dBm);

b.3.c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz and having an average output power greater than 0.5W (27 dBm);

b.3.d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and having an average output power greater than 1W (30 dBm); *or*

b.3.e. Rated for operation at frequencies exceeding 43.5 GHz.

● ***Note:*** *The control status of a transistor whose ratedoperating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.3.a through 3A001.b.3.e, is determined by the lowest average output power control threshold.*

b.4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave amplifiers having any of the following:

b.4.a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 60W (47.8 dBm) with a "fractional bandwidth" greater than 15%;

b.4.b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and with an average output power greater than 15W (42 dBm) with a "fractional bandwidth" greater than 10%;

b.4.c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;

b.4.d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;

b.4.e. Rated for operation at frequencies exceeding 43.5 GHz; *or*

b.4.f. Rated for operation at frequencies above 3.2 GHz and all of the following:

b.4.f.1. An average output power (in watts), P, greater than 150 divided by the maximum operating frequency (in GHz) squared [$P > 150\ W*GHz^2/f_{GHz}^2$];

b.4.f.2. A fractional bandwidth of 5% or greater; *and*

b.4.f.3. Any two sides perpendicular to one another with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [$d \leq 15\ cm*GHz/ f_{GHz}$].

● ***Technical Note:*** *3.2 GHz should be used as the lowest operating frequency ($f_{GHz}$) in the formula in 3A001.b.4.f.3., for amplifiers that have a rated operation range extending downward to 3.2 GHz and below [$d \leq 15cm*GHz/3.2\ f_{GHz}$].*

***N.B.:*** *MMIC power amplifiers should be evaluated against the criteria in 3A001.b.2.*

***Note 1:*** *3A001.b.4. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.*

● ***Note 2:*** *The control status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.4.a through 3A001.b.4.e, is determined by the lowest average output power control threshold.*

b.5. Electronically or magnetically tunable band-pass or band-stop filters having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band ($f_{max}/f_{min}$) in less than 10 µs having any of the following:

b.5.a. A band-pass bandwidth of more than 0.5% of center frequency; *or*

b.5.b. A band-stop bandwidth of less than 0.5% of center frequency;

b.6. [RESERVED]

b.7. Mixers and converters designed to extend the frequency range of equipment described in 3A002.c, 3A002.e or 3A002.f beyond the limits stated therein;

b.8. Microwave power amplifiers containing tubes controlled by 3A001.b and having all of the following:

b.8.a. Operating frequencies above 3 GHz;

b.8.b. An average output power density exceeding 80 W/kg; *and*

b.8.c. A volume of less than 400 $cm^3$;

***Note*:** *3A001.b.8 does not control equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

c. Acoustic wave devices, as follows, and specially designed components therefor:

c.1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:

c.1.a. A carrier frequency exceeding 2.5 GHz;

c.1.b. A carrier frequency exceeding 1 GHz, but not exceeding 2.5 GHz, and having any of the following:

c.1.b.1. A frequency side-lobe rejection exceeding 55 dB;

c.1.b.2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;

c.1.b.3. A bandwidth greater than 250 MHz; or

c.1.b.4. A dispersive delay of more than 10 µs; *or*

c.1.c. A carrier frequency of 1 GHz or less, having any of the following:

c.1.c.1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;

c.1.c.2. A dispersive delay of more than 10 µs; *or*

c.1.c.3. A frequency side-lobe rejection exceeding 55 dB and a bandwidth greater than 50 MHz;

c.2. Bulk (volume) acoustic wave devices (i.e., "signal processing" devices employing elastic waves) that permit the direct processing of signals at frequencies exceeding 1 GHz;

c.3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves that permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

d. Electronic devices and circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:

d.1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than $10^{-14}$ J; *or*

d.2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;

e. High energy devices, as follows:

e.1. Batteries and photovoltaic arrays, as follows:

***Note*:** *3A001.e.1 does not control batteries with volumes equal to or less than 27 $cm^3$ (e.g., standard C-cells or R14 batteries).*

e.1.a. Primary cells and batteries having an energy density exceeding 480 Wh/kg and rated for operation in the temperature range from below 243 K (-30°C) to above 343 K (70°C);

e.1.b. Rechargeable cells and batteries having an energy density exceeding 150 Wh/kg after 75 charge/discharge cycles at a discharge current equal to C/5 hours (C being the nominal capacity in ampere hours) when operating in the temperature range from below 253 K (-20°C) to above 333 K (60°C);

***Technical Note*:** *Energy density is obtained by multiplying the average power in watts (average voltage in volts times average current in amperes) by the duration of the discharge in hours to 75% of the open circuit voltage divided by the total mass of the cell (or battery) in kg.*

e.1.c. "Space qualified" and radiation hardened photovoltaic arrays with a specific power exceeding 160 $W/m^2$ at an operating temperature of 301 K (28°C) under a tungsten illumination of 1 $kW/m^2$ at 2,800 K (2,527°C);

e.2. High energy storage capacitors, as follows:

e.2.a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) having all of the following:

e.2.a.1. A voltage rating equal to or more than 5 kV;

e.2.a.2. An energy density equal to or more than 250 J/kg; *and*

e.2.a.3. A total energy equal to or more than 25 kJ;

e.2.b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) having all of the following:

e.2.b.1. A voltage rating equal to or more than 5 kV;

e.2.b.2. An energy density equal to or more than 50 J/kg;

e.2.b.3. A total energy equal to or more than 100 J; *and*

e.2.b.4. A charge/discharge cycle life equal to or more than 10,000;

e.3. "Superconductive" electromagnets and solenoids specially designed to be fully charged or discharged in less than one second, having all of the following:

***Note*:** *3A001.e.3 does not control "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance*

*Imaging (MRI) medical equipment.*

e.3.a. Energy delivered during the discharge exceeding 10 kJ in the first second;

e.3.b. Inner diameter of the current carrying windings of more than 250 mm; *and*

e.3.c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm$^2$;

f. Rotary input type shaft absolute position encoders having any of the following:

f.1. A resolution of better than 1 part in 265,000 (18 bit resolution) of full scale; *or*

f.2. An accuracy better than ± 2.5 seconds of arc.

**3A002 General purpose electronic equipment, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Requirement Notes**: See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

LVS: $3000: 3A002.a, .e, .f, .g;
$5000: 3A002.b to .d

GBS: Yes for 3A002.a.1.;3A002.b (synthesized output frequency of 2.6 GHz or less and a "frequency switching time" of 0.3 ms or more); and 3A002.d (synthesized output frequency of 2.6 GHz or less and a "frequency switching time" of 0.3 ms or more)

CIV: Yes for 3A002.a.1 (provided all of the following conditions are met: 1) Bandwidths do not exceed: 4 MHz per track and have up to 28 tracks *or* 2 MHz per track and have up to 42 tracks; 2) Tape speed does not exceed 6.1 m/s; 3) They are not designed for underwater use; 4) They are not ruggedized for military use; *and* 5) Recording density does not exceed 653.2 magnetic flux sine waves per mm); 3A002.b (synthesized output frequency of 2.6 GHz or less; and a "frequency switching time" of 0.3 ms or more), 3A002.d (synthesized output frequency of 2.6 GHz or less; and a "frequency switching time" of 0.3 ms or more).

**List of Items Controlled**

*Unit*: Number
*Related Controls*: "Space qualified" atomic frequency standards defined in 3A002.g.2 are subject to the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121). See also 3A292 and 3A992.
*Related Definitions*: Constant percentage bandwidth filters are also known as octave or fractional octave filters.
*Items*:

a. Recording equipment, as follows, and specially designed test tape therefor:

a.1. Analog instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g., using a high density digital recording (HDDR) module), having any of the following:

a.1.a. A bandwidth exceeding 4 MHz per electronic channel or track;

a.1.b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; *or*

a.1.c. A time displacement (base) error, measured in accordance with applicable IRIG or EIA documents, of less than ± 0.1 μs;

***Note*:** *Analog magnetic tape recorders specially designed for civilian video purposes are not considered to be instrumentation tape recorders.*

a.2. Digital video magnetic tape recorders having a maximum digital interface transfer rate exceeding 360 Mbit/s;

***Note*:** 3A002.a.2 does not control digital video magnetic tape recorders specially designed for television recording using a signal format, which may include a compressed signal format, standardized or recommended by the ITU, the IEC, the SMPTE, the EBU , the ETSI, or the IEEE for civil television applications.

a.3. Digital instrumentation magnetic tape data recorders employing helical scan techniques or fixed head techniques, having any of the following:

a.3.a. A maximum digital interface transfer rate exceeding 175 Mbit/s; *or*

a.3.b. Being "space qualified";

***Note*:** *3A002.a.3 does not control analog magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.*

a.4. Equipment, having a maximum digital interface transfer rate exceeding 175 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;

a.5. Waveform digitizers and transient recorders having all of the following:

***N.B.*:** *See also 3A292.*

a.5.a. Digitizing rates equal to or more than 200 million samples per second and a resolution of 10 bits or more; *and*

a.5.b. A continuous throughput of 2 Gbit/s or more;

***Technical Note*:** *For those instruments with a parallel bus architecture, the continuous throughput rate is the highest word rate multiplied by the number of bits in a word. Continuous throughput is the fastest data rate the instrument can output to mass storage without the loss of any information while sustaining the sampling rate and analog-to-digital conversion.*

a.6. Digital instrumentation data recorders, using magnetic disk storage technique, having all of the following:

a.6.a. Digitizing rate equal to or more than 100 million samples per second and a resolution of 8 bits or more; *and*

a.6.b. A continuous throughput of 1 Gbit/s or more;

b. "Frequency synthesizer", "electronic assemblies" having a "frequency switching time" from one selected frequency to another of less than 1 ms;

c. Radio frequency "signal analyzers", as follows:

c.1. "Signal analyzers" capable of analyzing any frequencies exceeding 31.8 GHz but not exceeding 37.5 Ghz and having a 3 dB resolution bandwidth (RBW) exceeding 10 MHz;

c.2. "Signal analyzers" capable of analyzing frequencies exceeding 43.5 Ghz;

c.3. "Dynamic signal analyzers" having a "real-time bandwidth" exceeding 500 kHz;

***Note*:** *3A002.c.3 does not control those "dynamic signal analyzers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).*

d. Frequency synthesized signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master frequency, and having any of the following:

d.1. A maximum synthesized frequency exceeding 31.8 GHz, but not exceeding 43.5 GHz and rated to generate a pulse duration of less than 100 ns;

d.2. A maximum synthesized frequency exceeding 43.5 GHz;

d.3. A "frequency switching time" from one selected frequency to another of less than 1 ms; *or*

d.4. A single sideband (SSB) phase noise better than $-(126 + 20 \log_{10}F - 20 \log_{10}f)$ in dBc/Hz, where F is the off-set from the operating frequency in Hz and f is the operating frequency in MHz;

***Technical Note*:** *For the purposes of 3A002.d.1., 'pulse duration' is defined as the time interval between the leading edge of the pulse achieving 90% of the peak and the trailing edge of the pulse achieving 10% of the peak.*

***Note*:** *3A002.d does not control equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.*

e. Network analyzers with a maximum operating frequency exceeding 43.5 GHz;

f. Microwave test receivers having all of the following:

f.1. A maximum operating frequency exceeding 43.5 GHz; *and*

f.2. Being capable of measuring amplitude and phase simultaneously;

g. Atomic frequency standards having any of the following:

g.1. Long-term stability (aging) less (better) than $1 \times 10^{-11}$/month; *or*

g.2. Being "space qualified".

***Note*:** *3A002.g.1 does not control non-"space qualified" rubidium standards.*

**3A003 Spray cooling thermal management systems employing closed loop fluid handling and reconditioning equipment in a sealed enclosure where a dielectric fluid is sprayed onto electronic components using specially designed spray nozzles that are designed to maintain electronic components within their operating temperature range, and specially designed components therefor.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number of systems, components in $
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3A101 Electronic equipment, devices and components, other than those controlled by 3A001, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: MT, AT

| *Control(s)* | *Country Chart* |
|---|---|
| MT applies to entire entry | MT Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: Items controlled in 3A101.a are subject to the export licensing authority of the U.S. Department of State, Directorate of Defense Trade Controls (See 22 CFR part 121).
*Related Definitions*: N/A
*Items*:

a. Analog-to-digital converters, usable in "missiles", designed to meet military specifications for ruggedized equipment;

b. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and systems containing those accelerators, usable for the "missiles" or the subsystems of "missiles".

***Note:*** *3A101.b above does not include equipment specially designed for medical purposes.*

**3A201 Electronic components, other than those controlled by 3A001, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Also see 3A001.e.2

(capacitors) and 3A001.e.3 (superconducting electromagnets). (3) Superconducting electromagnets specially designed or prepared for use in separating uranium isotopes are subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR part 110).
*Related Definitions*: N/A
*Items*:

a. Pulse discharge capacitors having either of the following sets of characteristics:

a.1. Voltage rating greater than 1.4 kV, energy storage greater than 10 J, capacitance greater than 0.5 μF, and series inductance less than 50 nH; *or*

a.2. Voltage rating greater than 750 V, capacitance greater than 0.25 μF, and series inductance less than 10 nH;

b. Superconducting solenoidal electromagnets having all of the following characteristics:

b.1. Capable of creating magnetic fields greater than 2 T;

b.2. A ratio of length to inner diameter greater than 2;

b.3. Inner diameter greater than 300 mm; *and*

b.4. Magnetic field uniform to better than 1% over the central 50% of the inner volume;

***Note:*** *3A201.b does not control magnets specially designed for and exported "as parts of" medical nuclear magnetic resonance (NMR) imaging systems. The phrase "as part of" does not necessarily mean physical part in the same shipment; separate shipments from different sources are allowed, provided the related export documents clearly specify that the shipments are dispatched "as part of" the imaging systems.*

c. Flash X-ray generators or pulsed electron accelerators having either of the following sets of characteristics:

c.1. An accelerator peak electron energy of 500 keV or greater, but less than 25 MeV, and with a "figure of merit" (K) of 0.25 or greater; *or*

c.2. An accelerator peak electron energy of 25 MeV or greater, and a "peak power" greater than 50 MW;

***Note:*** *3A201.c does not control accelerators that are component parts of devices designed for purposes other than electron beam or X-ray radiation (electron microscopy, for example) nor those designed for medical purposes.*

***Technical Notes:***

*(1) The "figure of merit" K is defined as: $K = 1.7 \times 10^3 V^{2.65} Q$. V is the peak electron energy in million electron volts. If the accelerator beam pulse duration is less than or equal to 1 μs, then Q is the total accelerated charge in Coulombs. If the accelerator beam pulse duration is greater than 1 μs, then Q is the maximum accelerated charge in 1 μs. Q equals the intergral of i with respect to t, over the lesser of 1 μs or the time duration of the beam pulse*
*($Q = \int i\,dt$), where i is beam current in amperes and t is time in seconds.*

*(2) "Peak power" = (peak potential in volts) x (peak beam current in amperes).*

*(3) In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 μs or the duration of the bunched beam packet resulting from one microwave modulator pulse.*

*(4) In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.*

**3A225 Frequency changers (also known as converters or inverters) or generators, other than those described in 0B001.c.11, having all of the following characteristics (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Frequency changers (also known as converters or inverters) specially designed or prepared for use in separating uranium isotopes are subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR part 110).
*Related Definitions*: N/A
*Items*:

a. A multiphase output capable of providing a power of 40 W or more;

b. Capable of operating in the frequency range between 600 and 2000 Hz;

c. Total harmonic distortion below 10%; *and*

d. Frequency control better than 0.1%.

**3A226 High-power direct current power supplies, other than those described in 0B001.j.6, having both of the following characteristics (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Also see ECCN 3A227. (3) Direct current power supplies specially designed or prepared for use in separating uranium isotopes are subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR part 110).
*Related Definitions*: N/A
*Items*:

a. Capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 A or greater; *and*

b. Current or voltage stability better than 0.1% over a time period of 8 hours.

**3A227 High-voltage direct current power supplies, other than those described in 0B001.j.5, having both of the following characteristics (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Also see ECCN 3A226. (3) Direct current power supplies specially designed or prepared for use in separating uranium isotopes are subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR part 110).
*Related Definitions*: N/A
*Items*:

a. Capable of continuously producing, over a time period of 8 hours, 20 kV or greater with current output of 1 A or greater; *and*

b. Current or voltage stability better than 0.1% over a time period of 8 hours.

**3A228 Switching devices, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Also see ECCN 3A991.k.
*Related Definitions*: N/A
*Items*:

a. Cold-cathode tubes, whether gas filled or not, operating similarly to a spark gap, having all of the following characteristics:

a.1. Containing three or more electrodes;

a.2. Anode peak voltage rating of 2.5 kV or more;

a.3. Anode peak current rating of 100 A or more; *and*

a.4. Anode delay time of 10 microsecond or less.

***Technical Note:*** *3A228.a includes gas krytron tubes and vacuum sprytron tubes.*

b. Triggered spark-gaps having both of the

following characteristics:

b.1. An anode delay time of 15μs or less; *and*

b.2. Rated for a peak current of 500 A or more.

c. Modules or assemblies with a fast switching function having all of the following characteristics:

c.1. Anode peak voltage rating greater than 2 kV;

c.2. Anode peak current rating of 500 A or more; *and*

c.3. Turn-on time of 1μs or less.

**3A229 Firing sets and equivalent high-current pulse generators (for detonators controlled by 3A232), as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) High explosives and related equipment for military use are subject to the export licensing authority of the U.S. Department of State, Directorate of Defense Trade Controls (see 22 CFR part 121).
*Related Definitions*: In 3A229.b.5, "rise time" is defined as the time interval from 10% to 90% current amplitude when driving a resistive load.
*ECCN Controls*: 3A229.b includes xenon flash-lamp drivers.
*Items*:

a. Explosive detonator firing sets designed to drive multiple controlled detonators controlled by 3A232;

b. Modular electrical pulse generators (pulsers) having all of the following characteristics:

b.1. Designed for portable, mobile, or ruggedized use;

b.2. Enclosed in a dust-tight enclosure;

b.3. Capable of delivering their energy in less than 15 μs ;

b.4. Having an output greater than 100 A;

b.5. Having a "rise time" of less than 10 μs into loads of less than 40 ohms;

b.6. No dimension greater than 254 mm;

b.7. Weight less than 25 kg; *and*

b.8. Specified for use over an extended temperature range 223 K (-50° C) to 373 K (100° C) or specified as suitable for aerospace applications.

**3A230 High-speed pulse generators having both of the following characteristics (see List of**

**Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry.
*Related Definitions*: In 3A230.b, "pulse transition time" is defined as the time interval between 10% and 90% voltage amplitude.
*Items*:

a. Output voltage greater than 6 V into a resistive load of less than 55 ohms; *and*

b. "Pulse transition time" less than 500 ps.

**3A231 Neutron generator systems, including tubes, having both of the following characteristics (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number; parts and accessories in $ value
*Related Controls*: See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry.
*Related Definitions*: N/A
*Items*:

a. Designed for operation without an external vacuum system; *and*

b. Utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction.

**3A232 Detonators and multipoint initiation systems, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) High explosives and related equipment for military use are subject to the export licensing authority of the U.S. Department of State, Directorate of Defense Trade Controls (see 22 CFR part 121).
*Related Definitions*: N/A
*ECCN Controls*: This entry does not control detonators using only primary explosives, such as lead azide.
*Items*:

a. Electrically driven explosive detonators, as follows:

a.1. Exploding bridge (EB);

a.2. Exploding bridge wire (EBW);

a.3. Slapper;

a.4. Exploding foil initiators (EFI);

b. Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over an area greater than 5,000 $mm^2$ from a single firing signal with an initiation timing spread over the surface of less than 2.5 μs.

***Technical Note:*** *The detonators controlled by this entry all utilize a small electrical conductor (bridge, bridge wire or foil) that explosively vaporizes when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material, such as PETN (Pentaerythritoltetranitrate). In slapper detonators, the explosive vaporization of the electrical conductor drives a flyer or slapper across a gap and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by a magnetic force. The term exploding foil detonator may refer to either a EB or a slapper-type detonator. Also, the word initiator is sometimes used in place of the word detonator.*

**3A233 Mass spectrometers, other than those described in 0B002.g, capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, and ion sources therefor.**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: (1) See ECCNs 3E001 ("development" and "production") and 3E201 ("use") for technology for items controlled under this entry. (2) Mass spectrometers specially designed or prepared for analyzing on-line samples of $UF_6$ gas streams are subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR

part 110).
*Related Definitions*: N/A
*Items*:

a. Inductively coupled plasma mass spectrometers (ICP/MS);

b. Glow discharge mass spectrometers (GDMS);

c. Thermal ionization mass spectrometers (TIMS);

d. Electron bombardment mass spectrometers that have a source chamber constructed from, lined with or plated with materials resistant to $UF_6$;

e. Molecular beam mass spectrometers having either of the following characteristics:

e.1. A source chamber constructed from, lined with or plated with stainless steel or molybdenum and equipped with a cold trap capable of cooling to 193 K (-80° C) or less; *or*

e.2. A source chamber constructed from, lined with or plated with materials resistant to $UF_6$;

f. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

**3A292 Oscilloscopes and transient recorders other than those controlled by 3A002.a.5, and specially designed components therefor.**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: See ECCN 3E292 ("development", "production", and "use") for technology for items controlled under this entry.
*Related Definitions*: "Bandwidth" is defined as the band of frequencies over which the deflection on the cathode ray tube does not fall below 70.7% of that at the maximum point measured with a constant input voltage to the oscilloscope amplifier.
*Items*:

a. Non-modular analog oscilloscopes having a bandwidth of 1 GHz or greater;

b. Modular analog oscilloscope systems having either of the following characteristics:

b.1. A mainframe with a bandwidth of 1 GHz or greater; *or*

b.2. Plug-in modules with an individual bandwidth of 4 GHz or greater;

c. Analog sampling oscilloscopes for the analysis of recurring phenomena with an effective bandwidth greater than 4 GHz;

d. Digital oscilloscopes and transient recorders, using analog-to-digital conversion techniques, capable of storing transients by sequentially sampling single-shot inputs at successive intervals of less than 1 ns (greater than 1 giga-sample per second), digitizing to 8 bits or greater resolution and storing 256 or more samples.

***Note:*** *Specially designed components*

*controlled by this item are the following, for analog oscilloscopes:*

*1. Plug-in units;*

*2. External amplifiers;*

*3. Pre-amplifiers;*

*4. Sampling devices;*

*5. Cathode ray tubes.*

**3A980 Voice print identification and analysis equipment and parts, n.e.s.**

**License Requirements**

*Reason for Control*: CC

| *Control(s)* | *Country Chart* |
|---|---|
| CC applies to entire entry | CC Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Equipment in number
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3A981 Polygraphs (except biomedical recorders designed for use in medical facilities for monitoring biological and neurophysical responses); fingerprint analyzers, cameras and equipment, n.e.s.; automated fingerprint and identification retrieval systems, n.e.s.; psychological stress analysis equipment; electronic monitoring restraint devices; and specially designed parts and accessories, n.e.s.**

**License Requirements**

*Reason for Control*: CC

| *Control(s)* | *Country Chart* |
|---|---|
| CC applies to entire entry | CC Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Equipment in number
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3A991 Electronic devices and components not controlled by 3A001.**

**● License Requirements**

*Reason for Control:* AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Requirements Notes:**

1. Microprocessors with a "Composite Theoretical Performance" ("CTP") below 550 MTOPS listed

in subparagraphs (a)(2) or (a)(3) of this entry may be shipped NLR (No License Required) when destined to North Korea, provided restrictions set forth in other sections of the EAR (e.g., end-use restrictions), do not apply. See "Information on How to Calculate "Composite Theoretical Performance" ("CTP")" at the end of Category 3.

2. See 744.17 of the EAR for additional license requirements for commodities classified as 3A991.a.1.

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Equipment in number
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

a. "Microprocessor microcircuits", "microcomputer microcircuits", and microcontroller microcircuits having any of the following:

a.1. A "composite theoretical performance" ("CTP") of 6,500 million theoretical operations per second (MTOPS) or more and an arithmetic logic unit with an access width of 32 bit or more;

a.2. A clock frequency rate exceeding 25 MHz; *or*

a.3. More than one data or instruction bus or serial communication port that provides a direct external interconnection between parallel "microprocessor microcircuits" with a transfer rate of 2.5 Mbyte/s.

b. Storage integrated circuits, as follows:

b.1. Electrical erasable programmable read-only memories (EEPROMs) with a storage capacity;

b.1.a. Exceeding 16 Mbits per package for flash memory types; *or*

b.1.b. Exceeding either of the following limits for all other EEPROM types:

b.1.b.1. Exceeding 1 Mbit per package; *or*

b.1.b.2. Exceeding 256 kbit per package and a maximum access time of less than 80 ns;

b.2. Static random access memories (SRAMs) with a storage capacity:

b.2.a. Exceeding 1 Mbit per package; *or*

b.2.b. Exceeding 256 kbit per package and a maximum access time of less than 25 ns;

c. Analog-to-digital converters having any of the following:

- c.1. A resolution of 8 bit or more, but less than 12 bit, with an output rate greater than 100 million words per second;

- c.2. A resolution of 12 bit with an output rate greater than 5 million words per second;

- c.3. A resolution of more than 12 bit but equal to or less than 14 bit withan output rate greater than 500 thousand words per second; *or*

- c.4. A resolution of more than 14 bit with an output rate greater than 500 thousand words per second.

d. Field programmable logic devices having either of the following:

d.1. An equivalent gate count of more than 5000 (2 input gates); *or*

d.2. A toggle frequency exceeding 100 MHz;

e. Fast Fourier Transform (FFT) processors having a rated execution time for a 1,024 point complex FFT of less than 1 ms.

f. Custom integrated circuits for which either the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:

f.1. More than 144 terminals; *or*

f.2. A typical "basic propagation delay time" of less than 0.4 ns.

g. Traveling wave tubes, pulsed or continuous wave, as follows:

g.1. Coupled cavity tubes, or derivatives thereof;

g.2. Helix tubes, or derivatives thereof, with any of the following:

g.2.a. An "instantaneous bandwidth" of half an octave or more; *and*

g.2.b. The product of the rated average output power (expressed in kW) and the maximum operating frequency (expressed in GHz) of more than 0.2;

g.2.c. An "instantaneous bandwidth" of less than half an octave; *and*

g.2.d. The product of the rated average output power (expressed in kW) and the maximum operating frequency (expressed in GHz) of more than 0.4;

h. Flexible waveguides designed for use at frequencies exceeding 40 GHz;

i. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having either of the following:

i.1. A carrier frequency exceeding 1 GHz; *or*

i.2. A carrier frequency of 1 GHz or less; *and*

i.2.a. A frequency side-lobe rejection exceeding 55 Db;

i.2.b. A product of the maximum delay time and bandwidth (time in microseconds and bandwidth in MHz) of more than 100; *or*

i.2.c. A dispersive delay of more than 10 microseconds.

●j. Primary cells and batteries having an energy density exceeding 350 Wh/kg and rated for operation in the temperature range from below 243 K (-30°C) to above 343 K (70°C);

***Note:*** *3A991 .j does not control batteries with volumes equal to or less than 27 $cm^3$ (e.g., standard C-cells or UM-2 batteries).*

***Technical Note:*** *Energy density is obtained by multiplying the average power in watts (average voltage in volts times average current in amperes) by the duration of the discharge in hours to 75 percent of the open circuit voltage divided by the total mass of the cell (or battery) in kg.*

k. "Superconductive" electromagnets or solenoids specially designed to be fully charged or discharged in less than one minute, having all of the following:

***Note:*** *3A991.k does not control "superconductive" electromagnets or solenoids designed for Magnetic Resonance Imaging (MRI)*

*medical equipment.*

k.1. Maximum energy delivered during the discharge divided by the duration of the discharge of more than 500 kJ per minute;

k.2. Inner diameter of the current carrying windings of more than 250 mm; *and*

k.3. Rated for a magnetic induction of more than 8T or "overall current density" in the winding of more than 300 A/mm$^2$.

l. Circuits or systems for electromagnetic energy storage, containing components manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents, having all of the following:

l.1. Resonant operating frequencies exceeding 1 MHz;

l.2. A stored energy density of 1 MJ/M$^3$ or more; *and*

l.3. A discharge time of less than 1 ms;

m. Hydrogen/hydrogen-isotope thyratrons of ceramic-metal construction and rate for a peak current of 500 A or more;

n. Digital integrated circuits based on any compound semiconductor having an equivalent gate count of more than 300 (2 input gates).

**3A992 General purpose electronic equipment not controlled by 3A002.**

**●License Requirements**

*Reason for Control:* AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $1000 for Syria for .a only
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Equipment in number
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

a. Electronic test equipment, n.e.s.

b. Digital instrumentation magnetic tape data recorders having any of the following any of the following characteristics;

b.1. A maximum digital interface transfer rate exceeding 60 Mbit/s and employing helical scan techniques;

b.2. A maximum digital interface transfer rate exceeding 120 Mbit/s and employing fixed head techniques; *or*

b.3. "Space qualified";

c. Equipment, with a maximum digital interface transfer rate exceeding 60 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;

**3A999 Specific processing equipment, n.e.s., as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry. A license is required for items controlled by this entry to North Korea for anti-terrorism reasons. The Commerce Country Chart is not designed to determine AT licensing requirements for this entry. See §742.19 of the EAR for additional information. | |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: See also 0B002, 3A225 (for frequency changes capable of operating in the frequency range of 600 Hz and above), 3A233
*Related Definitions*: N/A
*Items*:

a. Frequency changers capable of operating in the frequency range from 300 up to 600 Hz, n.e.s;

b. Mass spectrometers n.e.s;

c. All flash x-ray machines, and components of pulsed power systems designed thereof, including Marx generators, high power pulse shaping networks, high voltage capacitors, and triggers;

d. Pulse amplifiers, n.e.s.;

e. Electronic equipment for time delay generation or time interval measurement, as follows:

e.1. Digital time delay generators with a resolution of 50 nanoseconds or less over time intervals of 1 microsecond or greater; *or*

e.2. Multi-channel (three or more) or modular time interval meter and chronometry equipment with resolution of 50 nanoseconds or less over time intervals of 1 microsecond or greater;

f. Chromatography and spectrometry analytical instruments.

## B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

**3B001 Equipment for the manufacturing of semiconductor devices or materials, as follows (see List of Items Controlled), and specially designed components and accessories therefor.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Requirement Notes**: See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

LVS: $500
GBS: "Yes, except 3B001 .a.2 (metal organic chemical vapor deposition reactors), a.3 (molecular beam epitaxial growth equipment using gas sources), .e (automatic loading multi-chamber central wafer handling systems *only* if connected to equipment controlled by 3B001.a.2 and a.3, or .f), and .f (lithography equipment).
CIV: Yes for equipment controlled by 3B001.a.1.

## List of Items Controlled

*Unit*: Number
*Related Controls*: See also 3B991
*Related Definitions*: N/A
*Items*:

a. Equipment designed for epitaxial growth, as follows:

● a.1. Equipment capable of producing a layer of any material other than silicon with a thickness uniform to less than ± 2.5% across a distance of 75 mm or more;

a.2. Metal organic chemical vapor deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials controlled by 3C003 or 3C004;

a.3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. Equipment designed for ion implantation, having any of the following:

b.1. A beam energy (accelerating voltage) exceeding 1MeV;

b.2. Being specially designed and optimized to operate at a beam energy (accelerating voltage of less than 2 keV;

b.3. Direct write capability; *or*

b.4. A beam energy of 65 keV or more and a beam current of 45 mA or more for high energy oxygen implant into a heated semiconductor material "substrate";

c. Anisotropic plasma dry etching equipment, as follows:

c.1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:

c.1.a. Designed or optimized to produce critical dimensions of 180 nm or less with ± 5% 3 sigma precision; *or*

c.1.b. Designed for generating less than 0.04 particles/cm² with a measurable particle size greater than 0.1 μm in diameter;

c.2. Equipment specially designed for equipment controlled by 3B001.e. and having any of the following:

c.2.a. Designed or optimized to produce critical dimensions of 180 nm or less with ± 5% 3 sigma precision; *or*

c.2.b. Designed for generating less than 0.04 particles/cm² with a measurable particle size greater than 0.1 μm in diameter;

d. Plasma enhanced CVD equipment, as follows:

d.1. Equipment with cassette-to-cassette operation and load-locks, and designed according to the manufacturer's specifications or optimized for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

d.2. Equipment specially designed for equipment controlled by 3B001.e. and designed according to the manufacturer's specifications or optimized for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

e. Automatic loading multi-chamber central wafer handling systems, having all of the following:

e.1. Interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; *and*

e.2. Designed to form an integrated system in

a vacuum environment for sequential multiple wafer processing;

***Note*:** *3B001.e. does not control automatic robotic wafer handling systems not designed to operate in a vacuum environment.*

f. Lithography equipment, as follows:

f.1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having any of the following:

f.1.a. A light source wavelength shorter than 245 nm; *or*

f.1.b. Capable of producing a pattern with a minimum resolvable feature size of 180 nm or less;

***Technical Note*:** *The minimum resolvable feature size is calculated by the following formula:*

$$MRF = \frac{(\text{an exposure light source wavelength in nm}) \times (K \text{ factor})}{\text{numerical aperture}}$$

*where the K factor = 0.45*
*MRF = minimum resolvable feature size.*

f.2. Equipment specially designed for mask making or semiconductor device processing using deflected focused electron beam, ion beam or "laser" beam, having any of the following:

f.2.a. A spot size smaller than 0.2 μm;

f.2.b. Being capable of producing a pattern with a feature size of less than 1 μm; *or*

f.2.c. An overlay accuracy of better than ± 0.20 μm (3 sigma);

g. Masks and reticles designed for integrated circuits controlled by 3A001;

h. Multi-layer masks with a phase shift layer.

***Note*:** *3B001.h. does not control multi-layer masks with a phase shift layer designed for the fabrication of memory devices not controlled by 3A001.*

**3B002 Test equipment, specially designed for testing finished or unfinished semiconductor devices, as follows (see List of Items Controlled), and specially designed components and accessories therefor.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $500
GBS: Yes
CIV: N/A

**List of Items Controlled**

*Unit*: Number
*Related Controls*: See also 3B992
*Related Definitions*: N/A
*Items*:

a. For testing S-parameters of transistor devices at frequencies exceeding 31.8 GHz;

b. [RESERVED]

c. For testing microwave integrated circuits controlled by 3A001.b.2.

**3B991 Equipment not controlled by 3B001 for the manufacture of electronic components and materials, and specially designed components and accessories therefor.**

**License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

- *Unit*: Equipment in number, and components and accessories in $ value
  *Related Controls*: N/A
  *Related Definitions*: 'Sputtering' is an overlay coating process wherein positively charged ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on the substrate. (Note: Triode, magnetron or radio frequency sputtering to increase adhesion of coating and rate of deposition are ordinary modifications of the process.)
  *Items*:

a. Equipment specially designed for the manufacture of electron tubes, optical elements and specially designed components therefor controlled by 3A001 or 3A991;

b. Equipment specially designed for the manufacture of semiconductor devices, integrated circuits and "electronic assemblies", as follows, and systems incorporating or having the characteristics of such equipment:

***Note*:** *3B991.b also controls equipment used or modified for use in the manufacture of other devices, such as imaging devices, electro-optical devices, acoustic-wave devices.*

b.1. Equipment for the processing of materials for the manufacture of devices and components as specified in the heading of 3B991.b, as follows:

***Note*:** *3B991 does not control quartz furnace tubes, furnace liners, paddles, boats (except specially designed caged boats), bubblers, cassettes or crucibles specially designed for the processing equipment controlled by 3B991.b.1.*

b.1.a. Equipment for producing polycrystalline silicon and materials controlled by 3C001;

b.1.b. Equipment specially designed for purifying or processing III/V and II/VI semiconductor materials controlled by 3C001, 3C002, 3C003, or 3C004, except crystal pullers, for which see 3B991.b.1.c below;

b.1.c. Crystal pullers and furnaces, as follows:

***Note*:** *3B991.b.1.c does not control diffusion and oxidation furnaces.*

b.1.c.1. Annealing or recrystallizing equipment other than constant temperature furnaces employing high rates of energy transfer capable of processing wafers at a rate exceeding

0.005 $m^2$ per minute;

b.1.c.2. "Stored program controlled" crystal pullers having any of the following characteristics:

b.1.c.2.a. Rechargeable without replacing the crucible container;

b.1.c.2.b. Capable of operation at pressures above 2.5 x $10^5$ Pa; *or*

b.1.c.2.c. Capable of pulling crystals of a diameter exceeding 100 mm;

b.1.d. "Stored program controlled" equipment for epitaxial growth having any of the following characteristics:

- b.1.d.1. Capable of producing a silicon layer with a thickness uniform to less than ±2.5% across a distance of 200 mm or more;

- b.1.d.2. Capable of producing a layer of any material other than silicon with a thickness uniformity across the wafer of equal to or better than ± 3.5%; *or*

- b.1.d.3. Rotation of individual wafers during processing;

b.1.e. Molecular beam epitaxial growth equipment;

b.1.f. Magnetically enhanced 'sputtering' equipment with specially designed integral load locks capable of transferring wafers in an isolated vacuum environment;

b.1.g. Equipment specially designed for ion implantation, ion-enhanced or photo-enhanced diffusion, having any of the following characteristics:

b.1.g.1. Patterning capability;

b.1.g.2. Beam energy (accelerating voltage) exceeding 200 keV;

b.1.g.3 Optimized to operate at a beam energy (accelerating voltage) of less than 10 keV; *or*

b.1.g.4. Capable of high energy oxygen implant into a heated "substrate";

b.1.h. "Stored program controlled" equipment for the selective removal (etching) by means of anisotropic dry methods (e.g., plasma), as follows:

b.1.h.1. Batch types having either of the following:

b.1.h.1.a. End-point detection, other than optical emission spectroscopy types; *or*

b.1.h.1.b. Reactor operational (etching) pressure of 26.66 Pa or less;

b.1.h.2. Single wafer types having any of the following:

b.1.h.2.a. End-point detection, other than optical emission spectroscopy types;

b.1.h.2.b. Reactor operational (etching) pressure of 26.66 Pa or less; *or*

b.1.h.2.c. Cassette-to-cassette and load locks wafer handling;

***Notes*:** *1. "Batch types" refers to machines not specially designed for production processing of single wafers. Such machines can process two or more wafers simultaneously with common process parameters, e.g., RF power, temperature, etch gas species, flow rates.*

*2. "Single wafer types" refers to machines specially designed for production processing of single wafers. These machines may use automatic*

*wafer handling techniques to load a single wafer into the equipment for processing. The definition includes equipment that can load and process several wafers but where the etching parameters, e.g., RF power or end point, can be independently determined for each individual wafer.*

b.1.i. "Chemical vapor deposition" (CVD) equipment, e.g., plasma-enhanced CVD (PECVD) or photo-enhanced CVD, for semiconductor device manufacturing, having either of the following capabilities, for deposition of oxides, nitrides, metals or polysilicon:

b.1.i.1. "Chemical vapor deposition" equipment operating below $10^5$ Pa; *or*

b.1.i.2. PECVD equipment operating either below 60 Pa (450 millitorr) or having automatic cassette-to-cassette and load lock wafer handling;

***Note*:** *3B991.b.1.i does not control low pressure "chemical vapor deposition" (LPCVD) systems or reactive "sputtering" equipment.*

b.1.j. Electron beam systems specially designed or modified for mask making or semiconductor device processing having any of the following characteristics:

b.1.j.1. Electrostatic beam deflection;

b.1.j.2. Shaped, non-Gaussian beam profile;

b.1.j.3. Digital-to-analog conversion rate exceeding 3 MHz;

b.1.j.4. Digital-to-analog conversion accuracy exceeding 12 bit; *or*

b.1.j.5. Target-to-beam position feedback control precision of 1 micrometer or finer;

***Note*:** *3B991.b.1.j does not control electron beam deposition systems or general purpose scanning electron microscopes.*

b.1.k. Surface finishing equipment for the processing of semiconductor wafers as follows:

b.1.k.1. Specially designed equipment for backside processing of wafers thinner than 100 micrometer and the subsequent separation thereof; *or*

b.1.k.2. Specially designed equipment for achieving a surface roughness of the active surface of a processed wafer with a two-sigma value of 2 micrometer or less, total indicator reading (TIR);

***Note*:** *3B991.b.1.k does not control single-side lapping and polishing equipment for wafer surface finishing.*

b.1.l. Interconnection equipment which includes common single or multiple vacuum chambers specially designed to permit the integration of any equipment controlled by 3B991 into a complete system;

b.1.m. "Stored program controlled" equipment using "lasers" for the repair or trimming of "monolithic integrated circuits" with either of the following characteristics:

b.1.m.1. Positioning accuracy less than ± 1 micrometer; *or*

b.1.m.2. Spot size (kerf width) less than 3 micrometer.

b.2. Masks, mask "substrates", mask-making equipment and image transfer equipment for the manufacture of devices and components as specified in the heading of 3B991, as follows:

***Note*:** *The term "masks" refers to those used in electron beam lithography, X-ray lithography,*

*and ultraviolet lithography, as well as the usual ultraviolet and visible photo-lithography.*

b.2.a. Finished masks, reticles and designs therefor, except:

b.2.a.1. Finished masks or reticles for the production of unembargoed integrated circuits; *or*

b.2.a.2. Masks or reticles, having both of the following characteristics:

b.2.a.2.a. Their design is based on geometries of 2.5 micrometer or more; *and*

b.2.a.2.b. The design does not include special features to alter the intended use by means of production equipment or "software";

b.2.b. Mask "substrates" as follows:

b.2.b.1. Hard surface (e.g., chromium, silicon, molybdenum) coated "substrates" (e.g., glass, quartz, sapphire) for the preparation of masks having dimensions exceeding 125 mm x 125 mm; *or*

b.2.b.2. "Substrates" specially designed for X-ray masks;

b.2.c. Equipment, other than general purpose computers, specially designed for computer aided design (CAD) of semiconductor devices or integrated circuits;

b.2.d. Equipment or machines, as follows, for mask or reticle fabrication:

b.2.d.1. Photo-optical step and repeat cameras capable of producing arrays larger than 100 mm x 100 mm, or capable of producing a single exposure larger than 6 mm x 6 mm in the image (i.e., focal) plane, or capable of producing line widths of less than 2.5 micrometer in the photoresist on the "substrate";

b.2.d.2. Mask or reticle fabrication equipment using ion or "laser" beam lithography capable of producing line widths of less than 2.5 micrometer; *or*

b.2.d.3. Equipment or holders for altering masks or reticles or adding pellicles to remove defects;

***Note*:** *3B991.b.2.d.1 and b.2.d.2 do not control mask fabrication equipment using photo-optical methods which was either commercially available before the 1st January, 1980, or has a performance no better than such equipment.*

b.2.e. "Stored program controlled" equipment for the inspection of masks, reticles or pellicles with:

b.2.e.1. A resolution of 0.25 micrometer or finer; *and*

b.2.e.2. A precision of 0.75 micrometer or finer over a distance in one or two coordinates of 63.5 mm or more;

***Note*:** *3B991.b.2.e does not control general purpose scanning electron microscopes except when specially designed and instrumented for automatic pattern inspection.*

b.2.f. Align and expose equipment for wafer production using photo-optical or X-ray methods, e.g., lithography equipment, including both projection image transfer equipment and step and repeat (direct step on wafer) or step and scan (scanner) equipment, capable of performing any of the following functions:

***Note*:** *3B991.b.2.f does not control photo-optical contact and proximity mask align and expose equipment or contact image transfer equipment.*

b.2.f.1. Production of a pattern size

of less than 2.5 micrometer;

b.2.f.2. Alignment with a precision finer than ± 0.25 micrometer (3 sigma);

b.2.f.3. Machine-to-machine overlay no better than ± 0.3 micrometer; *or*

b.2.f.4. A light source wavelength shorter than 400 nm;

b.2.g. Electron beam, ion beam or X-ray equipment for projection image transfer capable of producing patterns less than 2.5 micrometer;

***Note*:** *For focused, deflected-beam systems (direct write systems), see 3B991.b.1.j or b.10.*

b.2.h. Equipment using "lasers" for direct write on wafers capable of producing patterns less than 2.5 micrometer.

b.3. Equipment for the assembly of integrated circuits, as follows:

b.3.a. "Stored program controlled" die bonders having all of the following characteristics:

b.3.a.1. Specially designed for "hybrid integrated circuits";

b.3.a.2. X-Y stage positioning travel exceeding 37.5 x 37.5 mm; *and*

b.3.a.3. Placement accuracy in the X-Y plane of finer than ± 10 micrometer;

b.3.b. "Stored program controlled" equipment for producing multiple bonds in a single operation (e.g., beam lead bonders, chip carrier bonders, tape bonders);

b.3.c. Semi-automatic or automatic hot cap sealers, in which the cap is heated locally to a higher temperature than the body of the package, specially designed for ceramic microcircuit packages controlled by 3A001 and that have a throughput equal to or more than one package per minute.

***Note*:** *3B991.b.3 does not control general purpose resistance type spot welders.*

b.4. Filters for clean rooms capable of providing an air environment of 10 or less particles of 0.3 micrometer or smaller per 0.02832 $m^3$ and filter materials therefor.

**3B992 Equipment not controlled by 3B002 for the inspection or testing of electronic components and materials, and specially designed components and accessories therefor.**

**● License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: Equipment in number
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

a. Equipment specially designed for the inspection or testing of electron tubes, optical elements and specially designed components therefor controlled by 3A001 or 3A991;

b. Equipment specially designed for the inspection

or testing of semiconductor devices, integrated circuits and "electronic assemblies", as follows, and systems incorporating or having the characteristics of such equipment:

***Note*:** *3B992.b also controls equipment used or modified for use in the inspection or testing of other devices, such as imaging devices, electro-optical devices, acoustic-wave devices.*

b.1. "Stored program controlled" inspection equipment for the automatic detection of defects, errors or contaminants of 0.6 micrometer or less in or on processed wafers, "substrates", other than printed circuit boards or chips, using optical image acquisition techniques for pattern comparison;

***Note*:** *3B992.b.1 does not control general purpose scanning electron microscopes, except when specially designed and instrumented for automatic pattern inspection.*

b.2. Specially designed "stored program controlled" measuring and analysis equipment, as follows:

b.2.a. Specially designed for the measurement of oxygen or carbon content in semiconductor materials;

b.2.b. Equipment for line width measurement with a resolution of 1 micrometer or finer;

b.2.c. Specially designed flatness measurement instruments capable of measuring deviations from flatness of 10 micrometer or less with a resolution of 1 micrometer or finer.

b.3. "Stored program controlled" wafer probing equipment having any of the following characteristics:

b.3.a. Positioning accuracy finer than 3.5 micrometer;

b.3.b. Capable of testing devices having more than 68 terminals; *or*

b.3.c. Capable of testing at a frequency exceeding 1 GHz;

b.4. Test equipment as follows:

b.4.a. "Stored program controlled" equipment specially designed for testing discrete semiconductor devices and unencapsulated dice, capable of testing at frequencies exceeding 18 GHz;

***Technical Note*:** *Discrete semiconductor devices include photocells and solar cells.*

b.4.b. "Stored program controlled" equipment specially designed for testing integrated circuits and "electronic assemblies" thereof, capable of functional testing:

b.4.b.1. At a 'pattern rate' exceeding 20 MHz; *or*

b.4.b.2. At a 'pattern rate' exceeding 10 MHz but not exceeding 20 MHz and capable of testing packages of more than 68 terminals.

***Notes*:** *3B992.b.4.b does not control test equipment specially designed for testing:*

*1. Memories;*

*2. "Assemblies" or a class of "electronic assemblies" for home and entertainment applications; and*

*3. Electronic components, "assemblies" and integrated circuits not controlled by 3A001 or 3A991 provided such test equipment does not incorporate computing facilities with "user accessible programmability".*

***Technical Note*:** *For purposes of 3B992.b.4.b, 'pattern rate' is defined as the*

*maximum frequency of digital operation of a tester. It is therefore equivalent to the highest data rate that a tester can provide in non-multiplexed mode. It is also referred to as test speed, maximum digital frequency or maximum digital speed.*

b.4.c. Equipment specially designed for determining the performance of focal-plane arrays at wavelengths of more than 1,200 nm, using "stored program controlled" measurements or computer aided evaluation and having any of the following characteristics:

b.4.c.1. Using scanning light spot diameters of less than 0.12 mm;

b.4.c.2. Designed for measuring photosensitive performance parameters and for evaluating frequency response, modulation transfer function, uniformity of responsivity or noise; *or*

b.4.c.3. Designed for evaluating arrays capable of creating images with more than 32 x 32 line elements;

b.5. Electron beam test systems designed for operation at 3 keV or below, or "laser" beam systems, for non-contactive probing of powered-up semiconductor devices having any of the following:

b.5.a. Stroboscopic capability with either beam blanking or detector strobing;

b.5.b. An electron spectrometer for voltage measurements with a resolution of less than 0.5 V; *or*

b.5.c. Electrical tests fixtures for performance analysis of integrated circuits;

***Note*:** *3B992.b.5 does not control scanning electron microscopes, except when specially designed and instrumented for non-contactive probing of a powered-up semiconductor device.*

b.6. "Stored program controlled" multifunctional focused ion beam systems specially designed for manufacturing, repairing, physical layout analysis and testing of masks or semiconductor devices and having either of the following characteristics:

b.6.a. Target-to-beam position feedback control precision of 1 micrometer or finer; *or*

b.6.b. Digital-to-analog conversion accuracy exceeding 12 bit;

b.7. Particle measuring systems employing "lasers" designed for measuring particle size and concentration in air having both of the following characteristics:

b.7.a. Capable of measuring particle sizes of 0.2 micrometer or less at a flow rate of 0.02832 $m^3$ per minute or more; *and*

b.7.b. Capable of characterizing Class 10 clean air or better.

## C. MATERIALS

**3C001 Hetero-epitaxial materials consisting of a "substrate" having stacked epitaxially grown multiple layers of any of the following (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |

| | |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $3000
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: This entry does not control equipment or material whose functionality has been unalterably disabled are not controlled.
*Related Definitions*: III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).
*Items*:

a. Silicon;

b. Germanium;

c. Silicon Carbide; *or*

d. III/V compounds of gallium or indium.

**3C002 Resist material and "substrates" coated with controlled resists.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $3000
GBS: Yes for positive resists not optimized for photolithography at a wavelength of less than 365 nm, provided that they are not controlled by 3C002.b through .d.
CIV: Yes for positive resists not optimized for photolithography at a wavelength of less than 365 nm, provided that they are not controlled by 3C002.b through .d.

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: Silylation techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing.
*Items*:

a. Positive resists designed for semiconductor lithography specially adjusted (optimized) for use at wavelengths below 350 nm;

b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 μcoulomb/mm$^2$ or better;

c. All resists designed for use with X-rays, with a sensitivity of 2.5 mJ/mm$^2$ or better;

d. All resists optimized for surface imaging technologies, including silylated resists.

**3C003 Organo-inorganic compounds, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|

| | |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $3000
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: This entry controls only compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.
*Related Definition*: N/A
*Items*:

a. Organo-metallic compounds of aluminium, gallium or indium having a purity (metal basis) better than 99.999%;

b. Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%.

**3C004 Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: $3000
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definition*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

***Note**: This entry does not control hydrides containing 20% molar or more of inert gases or hydrogen.*

**3C992 Positive resists designed for semiconductor lithography specially adjusted (optimized) for use at wavelengths between 370 and 350 nm.**

**License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

LVS: N/A
GBS: N/A
CIV: N/A

**List of Items Controlled**

*Unit:* $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

## D. SOFTWARE

**3D001 "Software" specially designed for the "development" or "production" of equipment controlled by 3A001.b to 3A002.g or 3B (except 3B991 and 3B992).**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to "software" for equipment controlled by 3A001.b to 3A001.f, 3A002, and 3B | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Requirement Notes**: See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

CIV: N/A

TSR: Yes, except for "software" specially designed for the "development" or "production" of Traveling Wave Tube Amplifiers described in 3A001.b.8 having operating frequencies exceeding 18 GHz.

**List of Items Controlled**

*Unit*: $ value

*Related Controls*: "Software" specially designed for the "development" or "production" of the following equipment is under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121): 1.) When operating at frequencies higher than 31 GHz and "space qualified": Helix tubes (traveling wave tubes (TWT)) defined in 3A001.b.1.a.4.c; microwave solid state amplifiers defined in 3A001.b.4.b; microwave "assemblies" defined in 3A001.b.6; and traveling wave tube amplifiers (TWTA) defined in 3A001.b.8; 2.) "Space qualified" and radiation hardened photovoltaic arrays defined in 3A001.e.1.c (i.e., not having silicon cells or single, dual or triple junction solar cells that have gallium arsenide as one of the junctions), spacecraft/satellite solar concentrators and batteries; and 3.) "Space qualified" atomic frequency standards defined in 3A002.g.2. See also 3D101

*Related Definitions*: For purposes of photovoltaic arrays in 3A001.e.1.c, an array predominately consists of: a substrate; solar cells having silicon cells or having single, dual, and or triple junction solar cells that have gallium arsenide as one of the junctions; coverglass; ultra-violet coating(s); and bonding agent(s). Spacecraft/satellite: solar concentrators, power conditioners and or controllers, bearing and power transfer assembly, and or deployment hardware/systems are controlled under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121).

*Items*:

The list of items controlled is contained in the ECCN heading.

**3D002 "Software" specially designed for the "use" of any of the following (see List of Items Controlled).**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: Yes

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

a. Equipment controlled by 3B001.a. to f.; or

b. Equipment controlled by 3B002.

**3D003 Physics-based simulation "software" specially designed for the "development" of lithographic, etching or deposition processes for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor materials.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: Yes

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: 1.) Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology". 2.) 'Physics-based' in 3D003 means using computations to determine a sequence of physical cause and effect events based on physical properties (e.g., temperature, pressure, diffusion constants and semiconductor materials properties).
*Items*:

The list of items controlled is contained in the ECCN heading.

**3D004 "Software" specially designed for the "development" of the equipment controlled by 3A003.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A

TSR: Yes

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3D101 "Software" specially designed or modified for the "use" of equipment controlled by 3A101.b.**

**License Requirements**

*Reason for Control*: MT, AT

| *Control(s)* | *Country Chart* |
|---|---|
| MT applies to entire entry | MT Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3D980 "Software" specially designed for the "development", "production", or "use" of items controlled by 3A980 and 3A981.**

**License Requirements**

*Reason for Control*: CC, AT

| *Control(s)* | *Country Chart* |
|---|---|
| CC applies to entire entry | CC Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3D991 "Software" specially designed for the "development", "production", or "use" of electronic devices or components controlled by 3A991, general purpose electronic equipment controlled by 3A992, or manufacturing and test equipment controlled by 3B991 and 3B992; or "software" specially designed for the "use" of equipment controlled by 3B001.g and .h.**

**License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: $ value
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

## E. TECHNOLOGY

**●3E001 "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 3A (except 3A292, 3A980, 3A981, 3A991 or 3A992), 3B (except 3B991 or 3B992) or 3C (except 3C992).**

**License Requirements**

*Reason for Control*: NS, MT, NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to "technology" for items controlled by 3A001, 3A002, 3B001, 3B002, or 3C001 to 3C004 | NS Column 1 |
| MT applies to "technology" for equipment controlled by 3A001 or 3A101 for MT reasons | MT Column 1 |
| NP applies to "technology" for equipment controlled by 3A001, 3A201, or 3A225 to 3A233 for NP reasons | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Requirement Note:** See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

- CIV: N/A
  TSR: Yes, except N/A for MT, and "technology" specially designed for the "development" or "production" of Traveling Wave Tube Amplifiers described in 3A001.b.8 having operating frequencies exceeding 18 GHz.

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: 1.) See also 3E101 and 3E201. 2.) 3E001 does not control "technology" for the "development" or "production" of: (a) Microwave transistors operating at frequencies below 31 GHz; (b) Integrated circuits controlled by 3A001.a.3 to a.12, having all of the following: 1. Using "technology" of 0.7 micrometer or more, AND 2. Not incorporating multi-layer structures. 3.) The term multi-layer structures in this entry does not include devices incorporating a maximum of two metal layers and two polysilicon layers. 4.)"Technology" according to the General Technology Note for the "development" or "production" of the following commodities is under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121): (a) When operating at frequencies higher than 31 GHz and "space qualified": helix tubes (traveling wave tubes (TWT)) defined in 3A001.b.1.a.4.c; microwave solid state amplifiers defined in 3A001.b.4.b; microwave "assemblies" defined in 3A001.b.6; or traveling wave tube amplifiers (TWTA)

defined in 3A001.b.8; (b) "Space qualified" and radiation hardened photovoltaic arrays defined in 3A001.e.1.c (i.e., not having silicon cells or single, dual or triple junction solar cells that have gallium arsenide as one of the junctions), and spacecraft/satellite solar concentrators and batteries; and (c) "Space qualified" atomic frequency standards defined in 3A002.g.2.

*Related Definition*: For purposes of photovoltaic arrays in 3A001.e.1.c, an array predominately consists of: a substrate; solar cells having silicon cells or having single, dual, and or triple junction solar cells that have gallium arsenide as one of the junctions; coverglass; ultra-violet coating(s); and bonding agent(s). Spacecraft/satellite: solar concentrators, power conditioners and or controllers, bearing and power transfer assembly, and or deployment hardware/systems are controlled under the export licensing authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121).

*Items*:

The list of items controlled is contained in the ECCN heading.

***Note 1**: 3E001 does not control "technology" for the "development" or "production" of integrated circuits controlled by 3A001.a.3 to a.12, having all of the following:*

*a) Using "technology" of 0.5 µm or more; and*

*b) Not incorporating multi-layer structures.*

***Technical Note**: The term multi-layer structures in Note b does not include devices incorporating a maximum of three metal layers and three polysilicon layers.*

***Note 2**: 3E001 does not control "technology" for the "production" of equipment or components controlled by 3A003.*

**3E002 "Technology" according to the General Technology Note other than that controlled in 3E001 for the "development" or "production" of "microprocessor microcircuits", "microcomputer microcircuits" and microcontroller microcircuits having a "composite theoretical performance" ("CTP") of 530 million theoretical operations per second (MTOPS) or more and an arithmetic logic unit with an access width of 32 bits or more.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: Yes, for deemed exports, as described in §734.2(b)(2)(ii) of the EAR, of "technology" for the "development" or "production" of general purpose microprocessors with a "Composite Theoretical Performance" ("CTP") less than or equal to 40,000 MTOPS (regardless of word length or access width). Deemed exports under License Exception CIV are subject to a Foreign National Review (FNR) requirement, see §740.5 of the EAR for more information about the FNR. License Exception CIV does not apply to ECCN 3E002 technology also required for the development or production of items controlled under ECCNs beginning with 3A, 3B, or 3C, or to ECCN 3E002 technology also controlled under ECCN 3E003.

TSR: Yes

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

***Note**: 3E002 does not control "technology" for the "development" or "production" of integrated circuits controlled by 3A001.a.3 to a.12, having all of the following:*

*a) Using "technology" of 0.5 µm or more; and*

*b) Not incorporating multi-layer structures.*

***Technical Note**: The term multi-layer structures in Note b does not include devices incorporating a maximum of three metal layers and three polysilicon layers.*

**3E003 Other "technology" for the "development" or "production" of items described in the List of Items Controlled.**

**License Requirements**

*Reason for Control*: NS, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NS applies to entire entry | NS Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: Yes, except .f and .g

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: 1) Technology for the "development" or "production" of "space qualified" electronic vacuum tubes operating at frequencies of 31.8 GHz or higher, described in 3E003.g, is under the export license authority of the Department of State, Directorate of Defense Trade Controls (22 CFR part 121); 2) See 3E001 for silicon-on-insulation (SOI) technology for the "development" or "production" related to radiation hardening of integrated circuits.
*Related Definitions*: N/A
*Items*:

a. Vacuum microelectronic devices;

b. Hetero-structure semiconductor devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;

***Note:** 3E003.b does not control technology for high electron mobility transistors (HEMT) operating at frequencies lower than 31.8 GHz and hetero-junction bipolar transistors (HBT) operating at frequencies lower than 31.8 GHz.*

c. "Superconductive" electronic devices;

d. Substrates of films of diamond for electronic components;

e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;

f. Substrates of silicon carbide for electronic components;

g. Electronic vacuum tubes operating at frequencies of 31.8 GHz or higher.

**3E101 "Technology" according to the General Technology Note for the "use" of equipment or**

**"software" controlled by 3A001.a.1 or .2, 3A101, or 3D101.**

**License Requirements**

*Reason for Control*: MT, AT

| *Control(s)* | *Country Chart* |
|---|---|
| MT applies to entire entry | MT Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3E102 "Technology" according to the General Technology Note for the "development" of "software" controlled by 3D101.**

**License Requirements**

*Reason for Control*: MT, AT

| *Control(s)* | *Country Chart* |
|---|---|
| MT applies to entire entry | MT Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A

*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3E201 "Technology" according to the General Technology Note for the "use" of equipment controlled by 3A001.e.2 or .e.3, 3A201 or 3A225 to 3A233.**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to "technology" for equipment controlled by 3A001.e.2, or .e.3, 3A201 or 3A225 to 3A233 for NP reasons | NP Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the

ECCN heading.

**3E292 "Technology" according to the General Technology Note for the "development", "production", or "use" of equipment controlled by 3A292.**

**License Requirements**

*Reason for Control*: NP, AT

| *Control(s)* | *Country Chart* |
|---|---|
| NP applies to entire entry | NP Column 2 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**3E980 "Technology" specially designed for "development", "production", or "use" of items controlled by 3A980 and 3A981.**

**License Requirements**

*Reason for Control*: CC, AT

| *Control(s)* | *Country Chart* |
|---|---|
| CC applies to entire entry | CC Column 1 |
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**●3E991 "Technology" for the "development", "production", or "use" of electronic devices or components controlled by 3A991, general purpose electronic equipment controlled by 3A992, or manufacturing and test equipment controlled by 3B991 or 3B992, or materials controlled by 3C992.**

**License Requirements**

*Reason for Control*: AT

| *Control(s)* | *Country Chart* |
|---|---|
| AT applies to entire entry | AT Column 1 |

**License Exceptions**

CIV: N/A
TSR: N/A

**List of Items Controlled**

*Unit*: N/A
*Related Controls*: N/A
*Related Definitions*: N/A
*Items*:

The list of items controlled is contained in the ECCN heading.

**EAR99 Items subject to the EAR that are *not* elsewhere specified in this CCL Category *or* in any other category in the CCL are designated by the number *EAR99*.**

**Information on How to Calculate "Composite Theoretical Performance ("CTP")**

**Technical Note:**

**"COMPOSITE THEORETICAL PERFORMANCE" ("CTP")**

*Abbreviations used in this Technical Note*

"CE" "computing element"(typically an arithmetic logical unit)
FP floating point
XP fixed point
t execution time
XOR exclusive OR
CPU central processing unit
TP theoretical performance (of a single "CE")
"CTP" "composite theoretical performance" (multiple "CEs")
R effective calculating rate
WL word length
L word length adjustment
* multiply

Execution time t is expressed in microseconds, TP and "CTP" are expressed in millions of theoretical operations per second (MTOPS) and WL is expressed in bits.

*Outline of "CTP" calculation method*

"CTP" is a measure of computational performance given in MTOPS. In calculating the "CTP" of an aggregation of "CEs" the following three steps are required:

1. Calculate the effective calculating rate R for each "CE";

2. Apply the word length adjustment (L) to the effective calculating rate (R), resulting in a Theoretical Performance (TP) for each "CE";

3. If there is more than one "CE", combine the TPs, resulting in a "CTP" for the aggregation.

Details for these steps are given in the following sections.

**Note 1:** For aggregations of multiple "CEs" that have both shared and unshared memory subsystems, the calculation of "CTP" is completed hierarchically, in two steps: first, aggregate the groups of "CEs" sharing memory; second, calculate the "CTP" of the groups using the calculation method for multiple "CEs" not sharing memory.

**Note 2:** "CEs" that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display controllers) are not aggregated into the "CTP" calculation.

The following table shows the method of calculating the Effective Calculating Rate R for each "CE":

Step 1: *The effective calculating rate R*

| For "CEs" Implementing:<br>**Note:** Every "CE" must be evaluated independently. | Effective calculating Rate, R |
|---|---|
| XP only<br><br>($R_{xp}$) | 1<br>---<br>3 * ($t_{xp\ add}$)<br>if no add is implemented use:<br>1<br>---<br>($t_{xp\ mult}$)<br>If neither add nor multiply is implemented use the fastest available arithmetic operation as follows:<br>1<br>---<br>3 * $t_{xp}$<br>See Notes X & Z |
| FP only<br>($R_{fp}$) | max (1 / $t_{fp\ add}$ , 1 / $t_{fp\ mult}$)<br>See Notes X & Y |
| Both FP and XP<br>(R) | Calculate both<br>$R_{xp}$, $R_{fp}$ |
| For simple logic processors not implementing any of the specified arithmetic operations. | 1<br>---<br>3 * $t_{log}$<br>Where $t_{log}$ is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation.<br>See Notes X & Z |
| For special logic processors not using any of the specified arithmetic or logic operations. | R = R' * WL/64<br>Where R' is the number of results per second, WL is the number of *bits* upon which the logic operation occurs, and 64 is a factor to normalize to a 64 bit operation. |

**Note W:** For a pipelined "CE" capable of executing up to one arithmetic or logic operation every clock cycle after the pipeline is full, a pipelined rate can be established. The effective calculating rate (R) for such a "CE" is the faster of the pipelined rate or non-pipelined execution rate.

**Note X:** For a "CE" that performs multiple operations of a specific type in a single cycle (e.g., two additions per cycle or two identical logic operations per cycle), the execution time t is given

by:

$$t = \frac{\text{cycle time}}{\text{the number of identical operations per machine cycle}}$$

"CEs" that perform different types of arithmetic or logic operations in a single machine cycle are to be treated as multiple separate "CEs" performing simultaneously (e.g., a "CE" performing an addition and a multiplication in one cycle is to be treated as two "CEs", the first performing an addition in one cycle and the second performing a multiplication in one cycle). If a single "CE" has both scalar function and vector function, use the shorter execution time value.

**Note Y:** For the "CE" that does not implement FP add or FP multiply, but that performs FP divide:

$$R_{fp} = \frac{1}{t_{fpdivide}}$$

If the "CE" implements FP reciprocal but not FP add, FP multiply or FP divide, then

$$R_{fp} = \frac{1}{t_{fpreciprocal}}$$

If none of the specified instructions is implemented, the effective FP rate is 0.

**Note Z:** In simple logic operations, a single instruction performs a single logic manipulation of no more than two operands of given lengths. In complex logic operations, a single instruction performs multiple logic manipulations to produce one or more results from two or more operands.

Rates should be calculated for all supported operand lengths considering both pipelined operations (if supported), and non-pipelined operations using the fastest executing instruction for each operand length based on:

1. Pipelined or register-to-register operations. Exclude extraordinarily short execution times generated for operations on a predetermined operand or operands (for example, multiplication by 0 or 1). If no register-to-register operations are implemented, continue with (2).

2. The faster of register-to-memory or memory-to-register operations; if these also do not exist, then continue with (3).

3. Memory-to-memory.

In each case above, use the shortest execution time certified by the manufacturer.

Step 2: *TP for each supported operand length WL*

Adjust the effective rate R (or R') by the word length adjustment L as follows:

TP = R * L, where L = (1/3 + WL/96)

**Note:** The word length WL used in these calculations is the operand length in bits. (If an operation uses operands of different lengths, select the largest word length.) The combination of a mantissa ALU and an exponent ALU of a floating point processor or unit is considered to be one "CE" with a Word Length (WL) equal to the number of bits in the data representation (typically 32 or 64) for purposes of the "CTP" calculation.

This adjustment is not applied to specialized logic processors that do not use XOR instructions. In this case TP = R.

Select the maximum resulting value of TP for:

Each XP-only "CE" ($R_{xp}$);

Each FP-only "CE" ($R_{fp}$);

Each combined FP and XP "CE" (R);

Each simple logic processor not implementing any of the specified arithmetic operations; *and*

Each special logic processor not using any of the specified arithmetic or logic operations.

Step 3: *"CTP" for aggregations of "CEs", including CPUs.*

For a CPU with a single "CE", "CTP" = TP
(for "CEs" performing both fixed and floating point operations
TP = max ($TP_{fp}$, $TP_{xp}$))

"CTP" for aggregations of multiple "CEs" operating simultaneously is calculated as follows:

**Note 1:** For aggregations that do not allow all of the "CEs" to run simultaneously, the possible combination of "CEs" that provides the largest "CTP" should be used. The TP of each contributing "CE" is to be calculated at its maximum value theoretically possible before the "CTP" of the combination is derived.

**N.B.:** To determine the possible combinations of simultaneously operating "CEs", generate an instruction sequence that initiates operations in multiple "CEs", beginning with the slowest "CE" (the one needing the largest number of cycles to complete its operation) and ending with the fastest "CE". At each cycle of the sequence, the combination of "CEs" that are in operation during that cycle is a possible combination. The instruction sequence must take into account all hardware and/or architectural constraints on overlapping operations.

**Note 2:** A single integrated circuit chip or board assembly may contain multiple "CEs".

**Note 3:** [RESERVED]

**Note 4:** [RESERVED]

**Note 5:** "CTP" values must be aggregated for multiple "CEs" specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,- or multiple memory/"CE"- combinations operating simultaneously utilizing specially designed hardware.

$$\text{"CTP"} = TP_1 + C_2 * TP_2 + ... + C_n * TP_n,$$

where the TPs are ordered by value, with $TP_1$ being the highest, $TP_2$ being the second highest, ..., and $TP_n$ being the lowest. $C_i$ is a coefficient determined by the strength of the interconnection between "CEs", as follows:

For multiple "CEs" operating simultaneously and sharing memory:

$$C_2 = C_3 = C_4 = ... = C_n = 0.75$$

**Note 1:** When the "CTP" calculated by the above method does not exceed 194 MTOPS, the following formula may be used to calculate $C_i$:

$$C_i = \frac{0.75}{\sqrt{m}} \qquad (i = 2, ..., n)$$

where m = the number of "CEs" or groups of "CEs" sharing access.

provided:

1. The $TP_1$ of each "CE" or group of "CEs" does not exceed 30 MTOPS;

2. The "CEs" or groups of "CEs" share access to main memory (excluding cache memory) over a single channel; *and*

3. Only one "CE" or group of "CEs" can have use of the channel at any given time.

**N.B.:** This does not apply to items controlled under Category 3.

**Note 2:** "CEs" share memory if they access a common segment of solid state memory. This memory may include cache memory, main memory or other internal memory. Peripheral memory devices such as disk drives, tape drives or RAM disks are not included.

For Multiple "CEs" or groups of "CEs" not sharing memory, interconnected by one or more data channels:

$C_i = 0.75 * k_i$ (i = 2, ... , 32) (see Note below)
$= 0.60 * k_i$ (i = 33, ... , 64)
$= 0.45 * k_i$ (i = 65, ... , 256)
$= 0.30 * k_i$ (i > 256)

The value of $C_i$ is based on the number of "CE"s, not the number of nodes.

where $k_i =$ min $(S_i/K_r, 1)$, and
$K_r =$ normalizing factor of 20 MByte/s.
$S_i =$ sum of the maximum data rates (in units of MByte/s) for all data channels connected to the $i^{th}$ "CE" or group of "CEs" sharing memory.

When calculating a $C_i$ for a group of "CEs", the number of the first "CE" in a group determines the proper limit for $C_i$. For example, in an aggregation of groups consisting of 3 "CEs" each, the 22nd group will contain "CE"$_{64}$, "CE"$_{65}$ and "CE"$_{66}$. The proper limit for $C_i$ for this group is 0.60.

Aggregation (of "CEs" or groups of "CEs") should be from the fastest-to-slowest; i.e.:
$TP_1 \geq TP_2 \geq .... \geq TP_n$, and

in the case of $TP_i = TP_{i+1}$, from the largest to smallest; i.e.:
$C_i \geq C_{i+1}$

**Note:** The $k_i$ factor is not to be applied to "CEs" 2 to 12 if the $TP_i$ of the "CE" or group of "CEs" is more than 50 MTOPS; i.e., $C_i$ for "CEs" 2 to 12 is 0.75.